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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F04B 43/12, F16L 11/20

A1

(11) International Publication Number: WO 97/42412

(43) International Publication Date: 13 November 1997 (13.11.97)

(21) International Application Number: PCT/AU97/00273

(22) International Filing Date: 6 May 1997 (06.05.97)

(30) Priority Data:
PN 9700 6 May 1996 (06.05.96) AU

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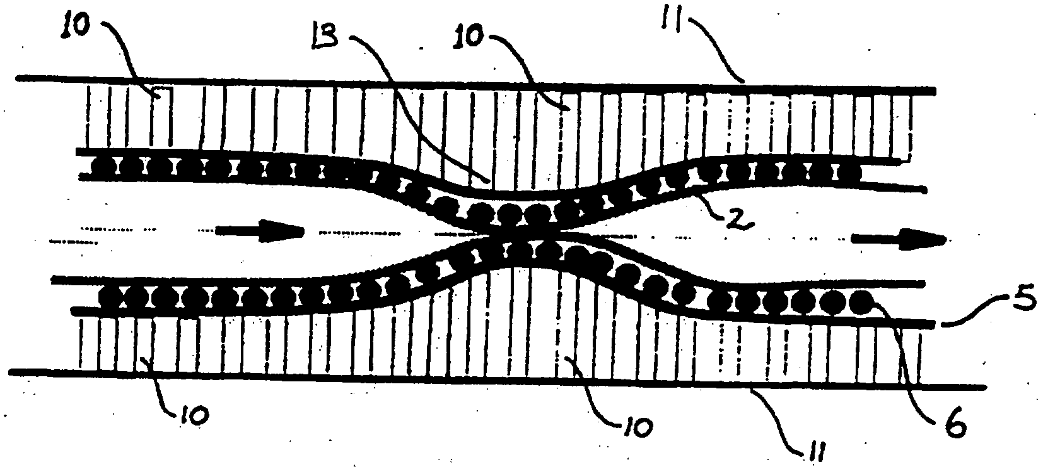
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: PSEUDO STATIC PERISTALTIC PUMP



(57) Abstract

A peristaltic pump comprises a flexible fluid conduit (2). A series of mutually opposed pairs of compression elements (10) are disposed externally along the length of the conduit (2). Progressive electrical stimulation of the pairs of elements, which may be flexible cells filled with polymer gel having piezoelectric properties, induces peristaltic compression (13) along the conduit. Radial expansion means in the form of a spiral tube (6) filled with a gas or a suitable polymer gel are operable to selectively expand the conduit (2) after passage of a compression wave. The spiral tube is divided, e.g., every four turns, into segments to optimise expansion characteristics. The conduit (2) has an elliptical cross section when in a relaxed state and this corresponds to the configuration of the conduit midway through a compression phase.

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TITLE: PSEUDO STATIC PERISTALTIC PUMP

FIELD OF THE INVENTION

The present invention relates generally to pumps, and more particularly to peristaltic type pumps.

The invention has been developed primarily for use in medical applications, and will therefore be described primarily with reference to this application. It will be appreciated, however, that the invention is not limited to this particular field of use, but may also be used in numerous other applications, a notable example being mineral slurry transportation.

BACKGROUND OF THE INVENTION

In the past, various attempts have been made to transport slurries over relatively long distances as a means, for example, of efficiently transporting coal, sand, cement and minerals. In most cases, however, conventional pumping technology has been found to be inadequate, particularly where longer distances are involved, because of the unusual fluid flow characteristics and other properties which many slurries typically exhibit.

For example, positive displacement type pumps incorporating various arrangements of pistons are often used to pump liquids. However, the vibrational pulses imparted by pumps of this type can cause blockages in hydraulic transport lines. Also, the valve characteristics inherent in piston type pumps typically render them inadequate for handling larger particles. This is due primarily to the susceptibility of the valves and valve seats to mechanical damage and rapid abrasive wear, as well as to the inability of the valves to pass larger particles.

Centrifugal pumps are also known and these tend to produce less vibration and accommodate a larger range of particle size. However, because of the rotary nature of such

pumps, rapid wear remains a common problem, particularly in shafts, bearings, seals and the like which translate into high capital and maintenance costs.

Peristaltic pumps are also known. These typically comprise compression elements such as pressure rollers which are passed in succession along the length of a flexible tube to induce fluid flow through the tube. In the past, however, such pumps have typically been unable to generate sufficient pressure or flow rate to be effective in large scale commercial operations. One problem is that if the tube is formed from a material sufficiently strong to withstand high internal pressures, it is then resistant to the required external compression from the pressure rollers, without relatively high energy inputs and consequential inefficiency and rapid mechanical wear. On the other hand, when more flexible tubes are used, these have a lower pressure capacity and a tendency to collapse, particularly on the suction side, thereby substantially diminishing the performance and efficiency of the pump. For these reasons, peristaltic pumps have hitherto been generally confined to low pressure or flow rate applications, such as in the medical field.

For example, numerous attempts have been made to produce a pump suitable for use in artificial hearts. In most cases, however, conventional pump technology has been found to be inadequate. Typical problems encountered with positive displacement pumps include mechanical failures due to the small size and intricate nature of the componentry, inadequate reliability due to excessive complexity or rapid wear, blockages caused by inadequate valve clearances, damage to blood cells due to the interaction of valve mechanisms, excessive power consumption due to electrical or mechanical inefficiency, and excessive bulk due to the basic limitations inherent in conventional pump technology.

Peristaltic pumps have been found to overcome several of these problems and are therefore used in some medical applications. In the past, however, these too have typically

been unable to provide the required combination of characteristics in terms of performance, efficiency, reliability and longevity for use in artificial hearts and other specialised applications. A particular problem again relates to the tendency of the primary tube to collapse over time, progressively diminishing the performance and efficiency of the pump, as well as requiring frequent replacement.

It is an object of the present invention to provide an improved pump which overcomes or substantially ameliorates at least some of these disadvantages of the prior art.

DISCLOSURE OF THE INVENTION

Accordingly, the invention as presently contemplated provides a peristaltic type pump comprising a primary flexible fluid conduit, a fluid inlet and a fluid outlet disposed at opposite ends of the conduit, compression means disposed along a length of the conduit, and actuation means adapted progressively to actuate the compression means in predetermined sequence so as to induce peristaltic compression along the length of the conduit and thereby move fluid from the inlet to the outlet of the pump.

Preferably, the compression means comprise a plurality of compression elements arranged as a series of discrete mutually opposed pairs. The compression elements of each pair are preferably movable alternately and in unison between an expanded configuration and a contracted configuration. The pairs are preferably actuated sequentially to induce peristaltic compression along the length of the primary conduit.

Each compression element preferably comprises a flexible cell containing a compression medium adapted to move between an expanded configuration corresponding to an activated state and a contracted configuration corresponding to a deactivated state in response to control stimuli from the actuation means. The compression medium is

preferably a polymer based piezoelectric gel and the control stimuli are preferably applied electric currents or voltages.

In the preferred embodiment, the pump further includes expansion means adapted to effect radial expansion of the primary conduit behind or upstream of each peristaltic compression wave. The expansion means preferably include a flexible jacket surrounding the primary conduit. The jacket preferably contains an expansion medium adapted selectively for localised pressurisation or expansion so as to increase hoop stresses and thereby to induce a circular cross-sectional profile in the primary conduit, immediately upstream of each compression wave.

In the preferred embodiment, the jacket includes a flexible secondary conduit or tube extending spirally around the outer periphery of the primary conduit to form a composite tube. The secondary conduit is preferably divided into discrete longitudinal expansion segments, each of which is filled with a polymer based piezoelectric gel. The expansion segments are preferably activated in predetermined phase relationship behind the compression elements, by electrical control stimuli from the actuation means.

In one particularly preferred embodiment, the spiral secondary conduit is formed within the side wall of the primary conduit, in which case the primary conduit, the secondary conduit and the outer jacket are effectively integral.

According to a second aspect, the invention provides a flexible primary tube for use with a peristaltic type pump as defined above, said tube being initially formed with an elliptical profile in a relaxed condition, as manufactured.

Preferably, the elliptical profile of the primary tube is defined by a minor axis X and a major axis Y, determined by the relationships:

$$X = \frac{D}{2}\text{; and} \quad Y = X \times 7^{0.5}$$

where D is the nominal internal diameter of the primary tube when fully expanded to a circular cross-sectional profile.

In this way, the inner circumference of the primary tube does not substantially change, despite variations in the cross-sectional profile during the compression cycles. Advantageously also, the elliptical profile reduces the extent of maximum deformation during each compression phase by effectively dividing the operational flexure into two opposite phases of bending, about a median position corresponding to the relaxed configuration of the tube, rather than a single bending phase of twice the magnitude.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a longitudinal cross-section showing a peristaltic pump according to a first embodiment of the invention;

Figure 2 is a transverse cross-sectional view taken along line 2-2 of Figure 1;

Figure 3 is a transverse cross-sectional view taken along line 3-3 of Figure 1;

Figure 4 is a longitudinal cross section showing a peristaltic pump according to a second embodiment of the invention;

Figure 5 is a transverse cross-sectional view taken along line 5-5 of Figure 4;

Figure 6 is a longitudinal cross section showing the electrical control inputs to the secondary spiral tube;

Figure 7 is a transverse cross-sectional view taken along line 7-7 of Figure 6;

Figure 8 is a longitudinal cross section showing a peristaltic pump according to a third embodiment of the invention;

Figure 9 is a transverse cross-sectional view taken along line 9-9 of Figure 8;

Figure 10 is a transverse cross-sectional view taken along line 10-10 of Figure 8;

Figure 11 is a transverse cross-section showing the elliptical profile of the composite tube, in a relaxed configuration as manufactured;

Figure 12 is a transverse section showing the composite tube of Figure 11 in a compressed configuration; and

Figure 13 is a transverse section showing the composite tube of Figure 11 in an expanded configuration.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to Figures 1 to 3, wherein corresponding features are denoted by corresponding reference numerals, the invention, according to a first embodiment, provides a peristaltic type pump 1 comprising a flexible primary fluid conduit 2 having a fluid inlet 3 and a fluid outlet 4. The primary conduit 2 is surrounded by radial expansion means in the form of a flexible jacket 5. The jacket 5 contains a secondary flexible tube 6 extending spirally around the outside of the primary tube. Alternatively, a composite tube may be provided with an internal spiral passage, in which case the primary conduit is defined by the inner surface of the composite tube, the surrounding jacket is defined by the outer surface of the composite tube and the secondary spiral conduit is defined within the sidewall of the tube, and all three are thus effectively integral. In another embodiment, the jacket 5 may simply be formed by a separate spiral tube, wound around and secured to the outer surface of the primary conduit, again to form a composite tube.

The pump further includes compression means in the form of a series of compression elements 10 arranged in corresponding mutually opposed pairs along the length of the primary tube, external to the secondary spiral tube 6. The compression elements are housed within a surrounding tubular casing 11 and annular end caps 12 which enable the assembly within the casing to be sealed and pressurised if required. The casing may also be flexible such that a degree of flexibility is afforded to the entire pump assembly.

The compression elements 10 take the form of flexible cells containing a compression medium adapted to move alternately between an expanded or active state and a contracted or inactive state in response to control stimuli from an actuation mechanism (not shown) which may include a microprocessor based controller. The compression medium is preferably a polymer based gel having piezoelectric characteristics, and as such expands in response to stimuli in the form of applied electric currents or voltages. It will be appreciated, however, that the compression elements may be solid, liquid or gaseous, and as such may take a variety of other forms. Also, it will be appreciated that any suitable number of compression elements may be used in a variety of configurations to provide the required flow characteristics.

The secondary spiral tube 6 also contains an expansion medium, preferably the same piezoelectric polymer gel as in the compression elements, adapted for controlled expansion so as selectively to increase the hoop stresses in, and thereby to effect radial expansion of, the primary conduit. The spiral tube is divided longitudinally into discrete segments, to provide optimum localised expansion characteristics. Each segment is approximately 4 turns in length, in a spiral defining a helix angle of between 1° and 20°, ideally around 5°.

In the second embodiment of the invention, as shown in Figures 4 to 7, the spiral segments are activated sequentially by control voltages applied where indicated to provide

localised control over the radial expansion mechanism, as described more fully below. In alternative arrangements a pump may be used to alternately pressurise and depressurise the segments to effect the desired radial expansion.

In a third embodiment of the invention, as shown in Figures 8 to 10, the spiral segments are only approximately two turns in length, and the compression elements are correspondingly sized to provide more precise shape control over the peristaltic compression waves during each pumping cycle.

Turning now to describe the operation of the pump in more detail, the actuator or controller (not shown) progressively activates the opposing piezoelectric compression elements 10 of each pair simultaneously, and the pairs in linear sequence, so as to induce a peristaltic compression wave 13 along the length of the primary conduit, thereby displacing fluid from the inlet 3 to the outlet 4 of the pump. At the same time, the controller activates the piezoelectric gel (or alternatively pressurises a fluid) contained in the surrounding spiral conduit 6. In the case of a longitudinally segmented spiral tube, the segments A, B, C, etc are progressively activated in linear succession immediately behind or upstream of the activated compression cells. This increases the hoop stresses in the primary conduit, and thereby tends to induce a circular cross-sectional profile in the primary conduit, following each compression wave. In other words, the control voltages applied to the compression cells are coordinated with the control voltages applied to the corresponding segments of the outer spiral tube, such that the peristaltic compression and subsequent positive expansion of the composite tube are appropriately synchronised. Advantageously, this enhances the negative pressure on the suction side of the pump and thereby improves the overall pumping efficiency. It also prevents the primary tube from permanently de-forming or collapsing into a flattened configuration over time in response to prolonged

compression cycles, as typically occurs in prior art pumps. This arrangement also obviates the need for moving parts and thereby offers significant benefits in terms of maintenance, reliability, size and cost. As such, it is particularly advantageous in medical applications.

It will be appreciated that by appropriate simultaneous or sequential activation of the compression elements, the pump may be configured to move fluid in either direction, as well as to act as a valve by blocking fluid flow altogether. In addition, it will be appreciated that surplus or redundant compression elements may be included as a safety feature. These would not normally be activated, but would remain in a standby mode, to be triggered by the actuator in the event of failure of active elements in the system.

Figures 11 to 13 show the shape and configuration of composite tube in more detail. Referring firstly to Figure 11, the tube is initially formed with an elliptical profile in the relaxed condition as manufactured, so as to reduce the extent of maximum deformation during each compression phase.. In terms of the pumping cycle, the elliptical profile of the conduit in the relaxed condition as shown in Figure 11 corresponds to the configuration of the conduit mid-way through a compression phase. In this way, it will be appreciated that the elliptical shape effectively divides the operational flexure into two opposite phases of bending, as shown in Figures 12 and 13 respectively, rather than a single phase of twice the magnitude. This in effect halves the maximum extent of deformation from the relaxed or equilibrium condition.

Most preferably, the composite tube is formed on an elliptical mandrel having a minor axis X and a major axis Y, as shown. If the internal diameter of the primary conduit in the fully expanded circular condition is D, then the following relationships are applied:-

$$X = \frac{D}{2}\text{; and} \quad Y = X \times 7^{0.5}$$

The significance of these mathematical relationships is that the inner circumference of the primary inner tube does not substantially change, despite variations in the cross-sectional profile during the compression cycles, which minimises internal stress and fatigue. However, the mean diameter of the spiral defined by the secondary tube is necessarily larger than the inner diameter of the primary tube and hence the mathematical identity no longer applies. Consequently, pressurisation of the secondary tube still induces the desired change from elliptical to circular profile on the suction side of each compression element, as described above. This arrangement thus optimises the service life of the composite tube, and enables the use of higher pressure capacity materials and designs which might otherwise lack the required degree of flexibility.

The present invention thus provides a peristaltic pump which is compact in size, flexible in configuration and operation, extremely reliable duc to the absence of moving parts, gentle to blood cells due to the absence of harsh mechanical valve interactions, and efficient in terms of power consumption. This makes the invention, optionally in a twin lobe configuration, ideal for use in medical applications and in particular for use in artificial hearts.

The present invention is also applicable to a wide variety of fluids and slurries with abrasive, corrosive or generally contaminate characteristics. It further has the capacity to be set up to generate a reasonable flow with only minimal compression in a dynamic pseudo wave action simply by reducing the control voltage to the compression elements. It may therefore accommodate relatively large particle size and may even be used to transfer live specimens, such as fish, between storage tanks. The invention is also particularly well adapted to pump relatively high viscosity liquids which in prior art pumps would cause the peristaltic tube on the suction side to collapse under atmospheric pressure. In all these

respects, the invention represents a commercially significant improvement over the prior art.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:-

1. A peristaltic type pump comprising a primary flexible fluid conduit, a fluid inlet and a fluid outlet disposed at opposite ends of the conduit, compression means disposed along a length of the conduit, and actuation means adapted progressively to actuate the compression means in predetermined sequence to induce peristaltic compression along the length of the conduit and thereby to move fluid from the inlet to the outlet of the pump.

2. A pump according to claim 1, wherein the compression means comprise a plurality of compression elements arranged as a series along the primary conduit and adapted for sequential actuation.

3. A pump according to claim 2, wherein said compression elements are arranged as a longitudinal series of discrete mutually opposed cooperating pairs.

4. A pump according to claim 3, wherein the compression elements of each pair are actuable in unison for alternate movement between an expanded configuration and a contracted configuration, and wherein the respective pairs are actuable sequentially to induce peristaltic compression along the primary conduit.

5. A pump according to claim 4, wherein each compression element comprises a flexible cell containing a compressive medium adapted to move between the expanded configuration corresponding to an activated state and the contracted configuration corresponding to a deactivated state, in response to control stimuli from said actuation means.

6. A pump according to claim 5, wherein said compressive medium is a polymer based gel formed from a piezoelectric material and wherein the control stimuli are electric currents or voltages applied by the actuation means.

7. A pump according to any one of the preceding claims, further including radial expansion means operable selectively to expand the primary conduit immediately upstream of each peristaltic compression wave.

8. A pump according to claim 7, wherein said expansion means include a jacket disposed around the primary conduit and containing an expansion medium adapted selectively for pressurisation or expansion, to increase the hoop stress and thereby to induce a substantially circular cross-sectional profile in the primary conduit immediately behind each compression wave.

9. A pump according to claim 8, wherein the jacket includes a flexible secondary conduit or tube extending spirally around the outer periphery of the primary conduit.

10. A pump according to claim 9, wherein the secondary spiral tube defines a helix angle of between 1° and around 20°.

11. A pump according to claim 10, wherein the secondary spiral tube defines a helix angle of approximately 5°.

12. A pump according to any one of claims 9 to 11, wherein the secondary tube is divided into discrete longitudinal segments.

13. A pump according to claim 12, wherein each of said segments is between 1 and around 10 turns in length.

14. A pump according to claim 13, wherein each of said segments is approximately 5 turns in length.

15. A pump according to claim 12, wherein each of said segments of the secondary spiral tube is filled with an expansion medium, and is thereby adapted for selective pressurisation or expansion in predetermined phase relationship with respect to the compression means, by the actuation means.

16. A pump according to claim 15, wherein the expansion medium comprises a polymer based piezoelectric gel.

17. A pump according to any one of claims 9 to 16, wherein the secondary spiral conduit is formed within a side wall of the primary conduit, such that the primary conduit, the secondary conduit, and the outer jacket are integrally formed as a unitary composite tube.

18. A pump according to claim 17, wherein the composite tube is manufactured in discrete longitudinal segments adapted for sealable connection in axially aligned relationship such that at least the primary conduit is effectively continuous across the segments.

19. A pump according to any one of claims 9 to 18, wherein the spiral conduit is wound around the outer periphery of the primary conduit and secured thereto, such that the jacket is integrally defined by the secondary tube.

20. A pump according to any one of the preceding claims, wherein the compression means and the primary conduit are disposed within an elongate generally tubular outer casing.

21. A pump according to claim 20, when dependent upon any one of claims 7 to 20, wherein said compression means are disposed within an annular clearance defined between the outer casing and the primary conduit, and around the radial expansion means.

22. A pump according to claim 21, wherein the outer casing is adapted to be pressurised with a liquid to reduce friction between moving parts and to enable the pump to accommodate relatively higher internal pressures.

23. A pump according to any one of claims 7 to 22, wherein the actuation means include a microprocessor based controller adapted to apply control voltages in predetermined

sequence and phase relationship to the compression means and to the expansion means respectively.

24. A pump according to any one of the preceding claims, wherein at least the primary conduit is initially formed with an elliptical internal cross-sectional profile in a relaxed condition as manufactured, so as to reduce the extent of maximum deformation during each compression phase.

25. A pump according to any one of claims 9 to 24, wherein a composite tube including the primary tube and the secondary spiral tube is initially formed with an elliptical internal cross-sectional profile in a relaxed condition, as manufactured.

26. A pump according to claim 24 or claim 25, wherein the elliptical profile of the primary tube is defined by a minor axis X and a major axis Y, determined by the relationships:

$$X = \frac{D}{2}\text{; and} \qquad Y = X \times 7^{0.5}$$

where D is the nominal internal diameter of the primary tube when fully expanded to a circular cross-sectional profile.

27. A pump according to any one of claims 24 to 26, wherein the elliptical profile of the primary tube is determined such that the inner circumference does not substantially alter despite variations in cross-sectional profile during peristaltic compression cycles.

28. A flexible tube adapted for use with a peristaltic type pump as defined in any one of the preceding claims, said tube being formed with an elliptical internal cross sectional profile in a relaxed condition, as manufactured.

29. A flexible tube according to claim 28, wherein the elliptical internal profile of the primary tube is defined by a minor axis X and a major axis Y, determined by the relationships:

$$X = \frac{D}{2}\text{; and} \qquad Y = X \times 7^{0.5}$$

where D is the nominal internal diameter of the tube when fully expanded to a circular cross-sectional profile.

30. A flexible tube according to claim 28 or claim 29, wherein the elliptical internal profile of the primary tube is determined such that the inner circumference does not substantially alter despite variations in cross-sectional profile during peristaltic compression cycles.

31. A composite tube for use in a pump as defined in any one of claims 1 to 30, said composite tube comprising a primary inner tube to contain a primary fluid to be pumped, and an outer jacket adapted to contain a secondary expansion medium in one or more segments defined between the primary inner tube and the outer jacket.

32. A composite tube according to claim 31, further including one or more secondary flexible tube segments spirally formed around the outside of the primary tube.

33. A composite tube according to claim 32, wherein the primary inner tube, the outer jacket, and the intermediate spiral tube segments are formed from separate components.

34. A composite tube according to claim 32, wherein the primary inner tube, the outer jacket and the intermediate spiral tube segments are effectively integral.

35. A composite tube according to claim 34, wherein the secondary tube is formed as a spiral cavity in the side wall of a unitary tube such that the inner surface of the unitary tube defines the primary conduit, the outer surface of the unitary tube forms the outer

jacket, and the spiral cavity within the side wall of the tube forms at least a segment of the secondary conduit.

36. A peristaltic type pump substantially as hereinbefore described, with reference to the accompanying drawings.

37. A flexible tube for use with a peristaltic type pump, said flexible tube being substantially as hereinbefore described, with reference to the accompanying drawings.

38. A composite tube for use with a peristaltic type pump, said composite tube being substantially as hereinbefore described, with reference to the accompanying drawings.

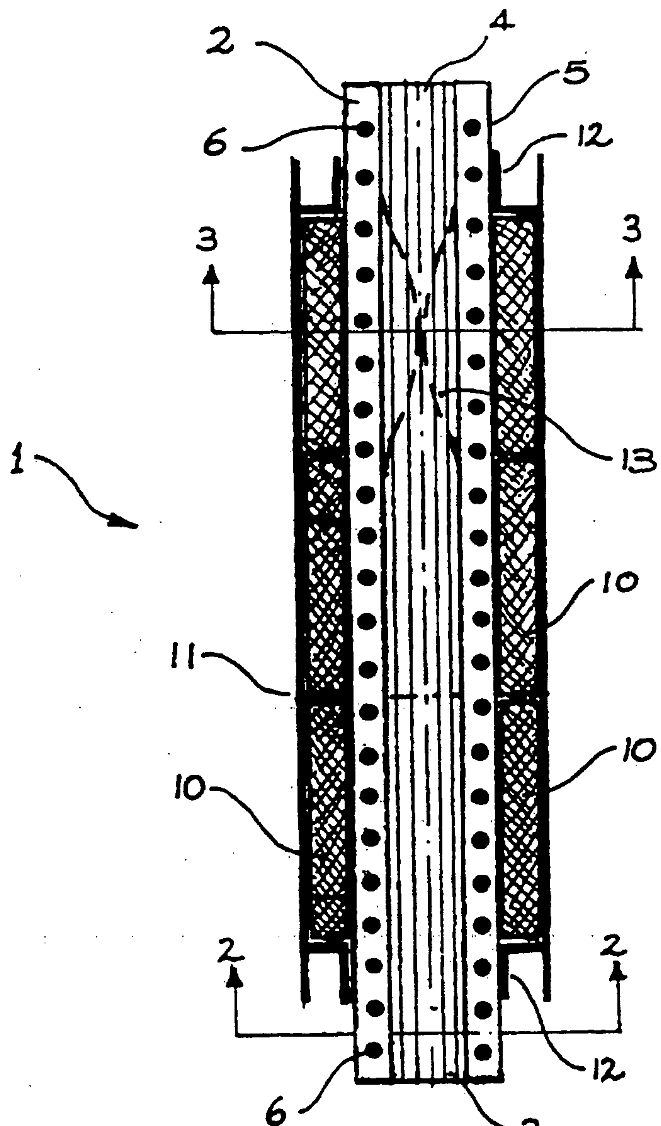

FIGURE 1

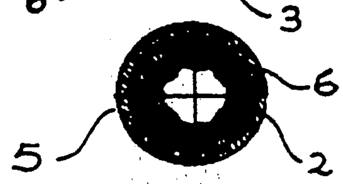

FIGURE 2

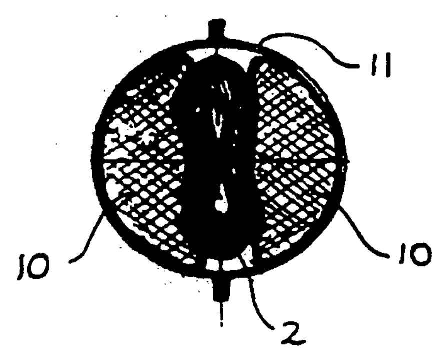

FIGURE 3

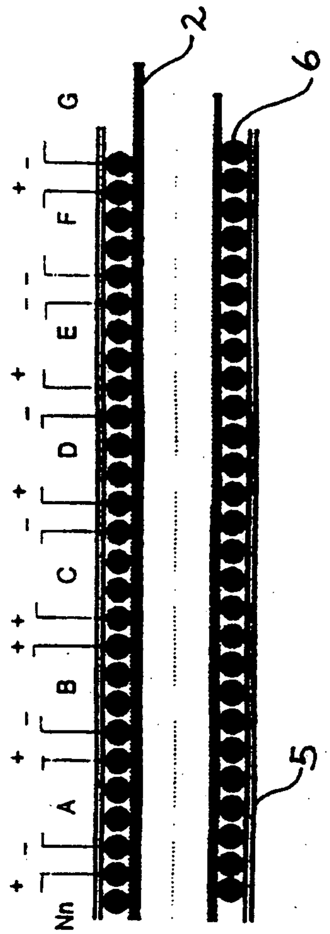

FIGURE 6

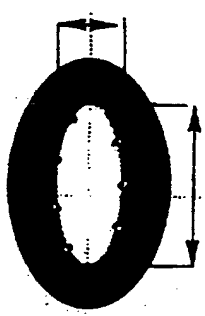

FIGURE 7

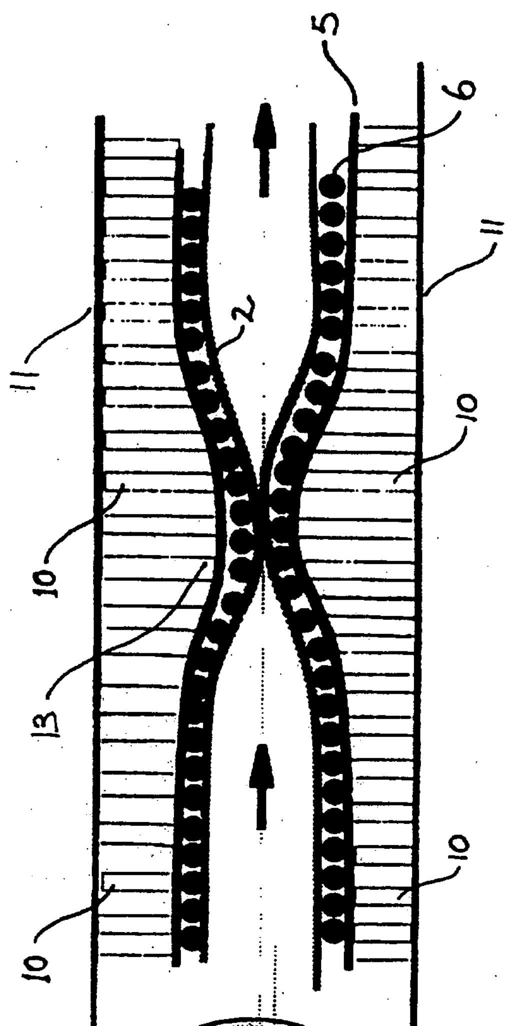

FIGURE 4

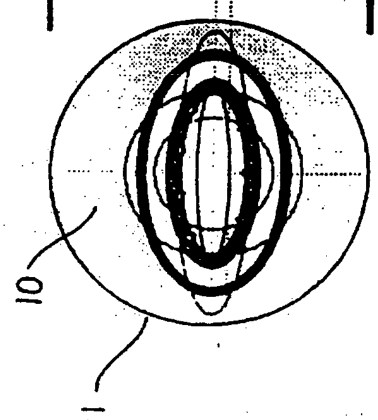

FIGURE 5

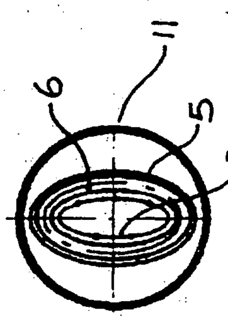

FIGURE 10

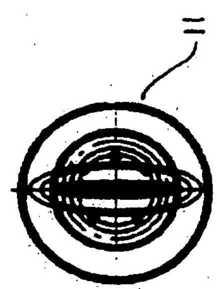

FIGURE 9

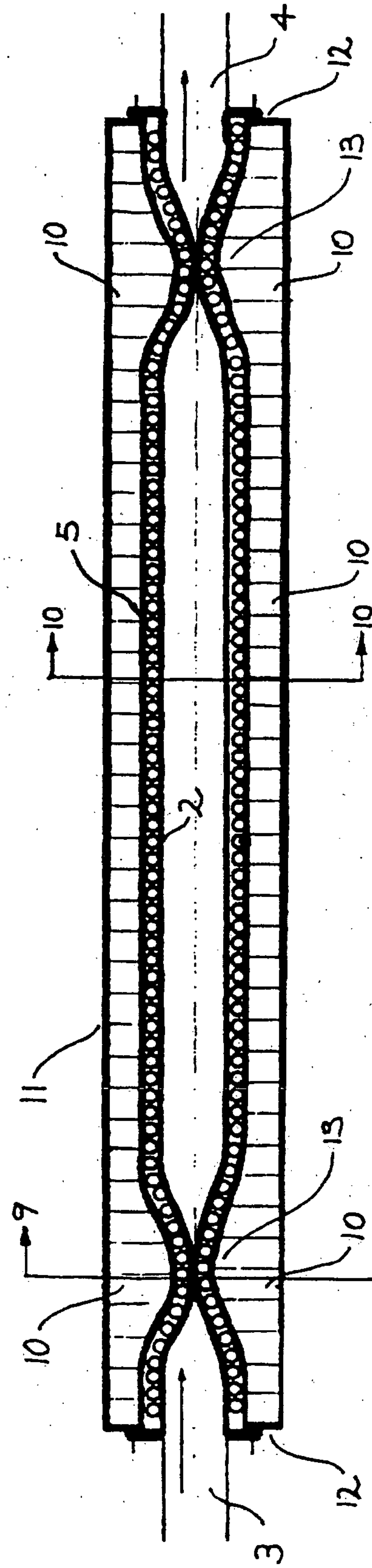

FIGURE 8

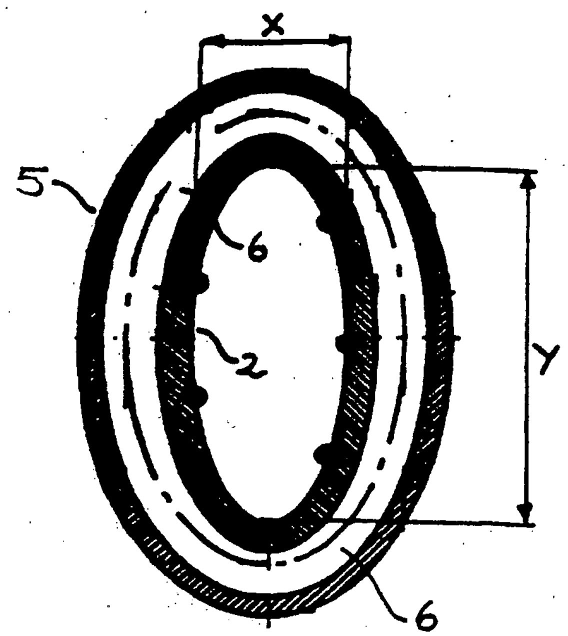

FIGURE 11

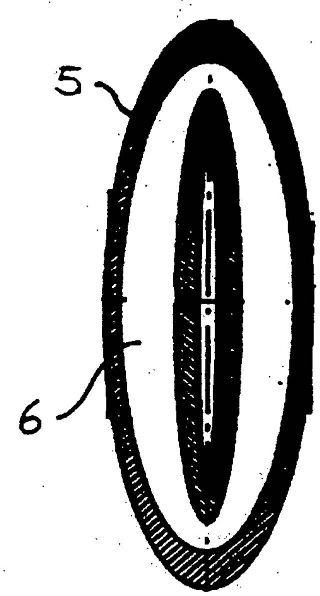

FIGURE 12

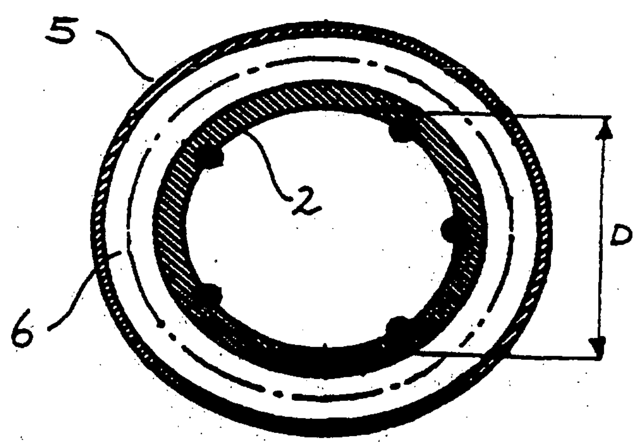

FIGURE 13

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00273

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl^6: F04B 43/12, F16L 11/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B 43/12, 45/08, F16L 11/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT: [(F04B 43/12 OR 45/08) AND (SER: OR SEQUEN: OR LINEAR OR STRAIGHT:)]
NOT (ROTARY OR ROLL:)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4115036 A (PATERSON) 19 September 1978 See whole document, in particular lines 23-31 of column 5	1-4
X	WO 96/05434 A (IVAC CORPORATION) 22 February 1996 See whole document	1-3, 7
X	Patent Abstracts of Japan, M1141, page 19, JP 3-107585 A (FUJITSU LTD) 7 May 1991	1-2

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 1997	03 JUL 1997

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (06) 285 3929	IAN KILBEY Telephone No.: (06) 283 2115

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00273

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent abstracts of Japan, JP. 7-27056 A (HITACHI LTD 27 January 1995	1-2
X A	US 4893991 A (HEMINWAY) 16 January 1990 See whole document	1-2 24, 28
X	DE 3723463 A (NAGEL) 26 January 1989 See whole document	1-2
X	Derwent abstract Accession No. 93-270506/34, class Q56, SU 1753038 A (KHARK TRACTOR WKS) 7 August 1992	1-2
X	Derwent Abstract Accession No. C 6605K/08, class Q56, SU 918515 A (GROZN PROMAVTOMATIK) 17 April 1982	31-35
X	Derwent Abstract Accession No. 95-102421/14, class Q67, JP 7-27260 A (BRIDGESTONE CORP) 27 January 1995	31
X	US 5468129 A (SUNDEN) 21 November 1995 See: column 6 lines 38-63, Fig. 2B	28, 30
X	US 5088522 A (RATH) 18 February 1992 See: column 3 lines 47-48, Figs. 1, 4	28, 30
X	FR 2479914 A (MEDTRONIC INC) 9 October 1981 See whole document, eg. lines 20-23 of page 2	28, 30

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 97/00273

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4115036	DE	2707713	FR	2343140	GB	1530662
		JP	52106103				
WO	9605434	US	5513957				
US	5468129	EP	774075	WO	9604480	US	5482447
US	5088522	DE	3909657	EP	388596	JP	3015682
FR	2479914	CA	1158477	DE	3112837	JP	56151057
		NL	8101619				

END OF ANNEX